ET820982 - Low IQ Synchronous Boost with Integrated LDO

General Description

The ET820982 is a low power synchronous boost converter. It integrates a Low-dropout Linear Regulator (LDO) with a boost converter and provides two output rails. The boost output V_{MAIN} is designed as an always-on supply for a main system, and the LDO output V_{SUB} is designed as an always-on supply for power peripheral devices.

The ET820982 supports automatic pass-through function. When input voltage is higher than pass-through threshold, the boost converter stops switching and passes the input voltage to the V_{MAIN} rail; when input voltage is lower than the threshold, the boost works in Boost mode and regulates the output at the target value.

The ET820982 can provide up to 50mA total output current at 0.7V input to 3.3V output conversion and with maximum efficiency at minimal quiescent current.

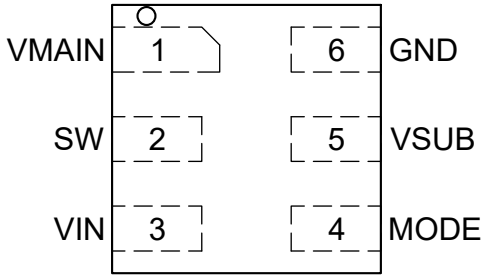
Features

- 4uA low I_Q in low power mode
- Start-up into load at 0.7V input voltage
- Operating input voltage from 0.7V to 4.5V
- Fixed output voltages：V_{MAIN} =3.3V，V_{SUB}=2.8V
- Minimum 350mA switch peak current limit
- Integrated LDO
- Two modes controlled by MODE pin
  - -- Active mode: dual outputs at set values
  - -- Low power mode: LDO and Boost keeps on with low IQ
- Automatic pass-through
- Up to 93% efficiency at 5mA to 100mA load from 2V to 3.3V conversion
- DFN6 (1.5mm × 1.5mm) package

Applications

- Smart remote control
- Wearable applications
- Low-power wireless applications
- Single-coin cell, single- or two-cell alkaline- powered applications

Pin Configuration

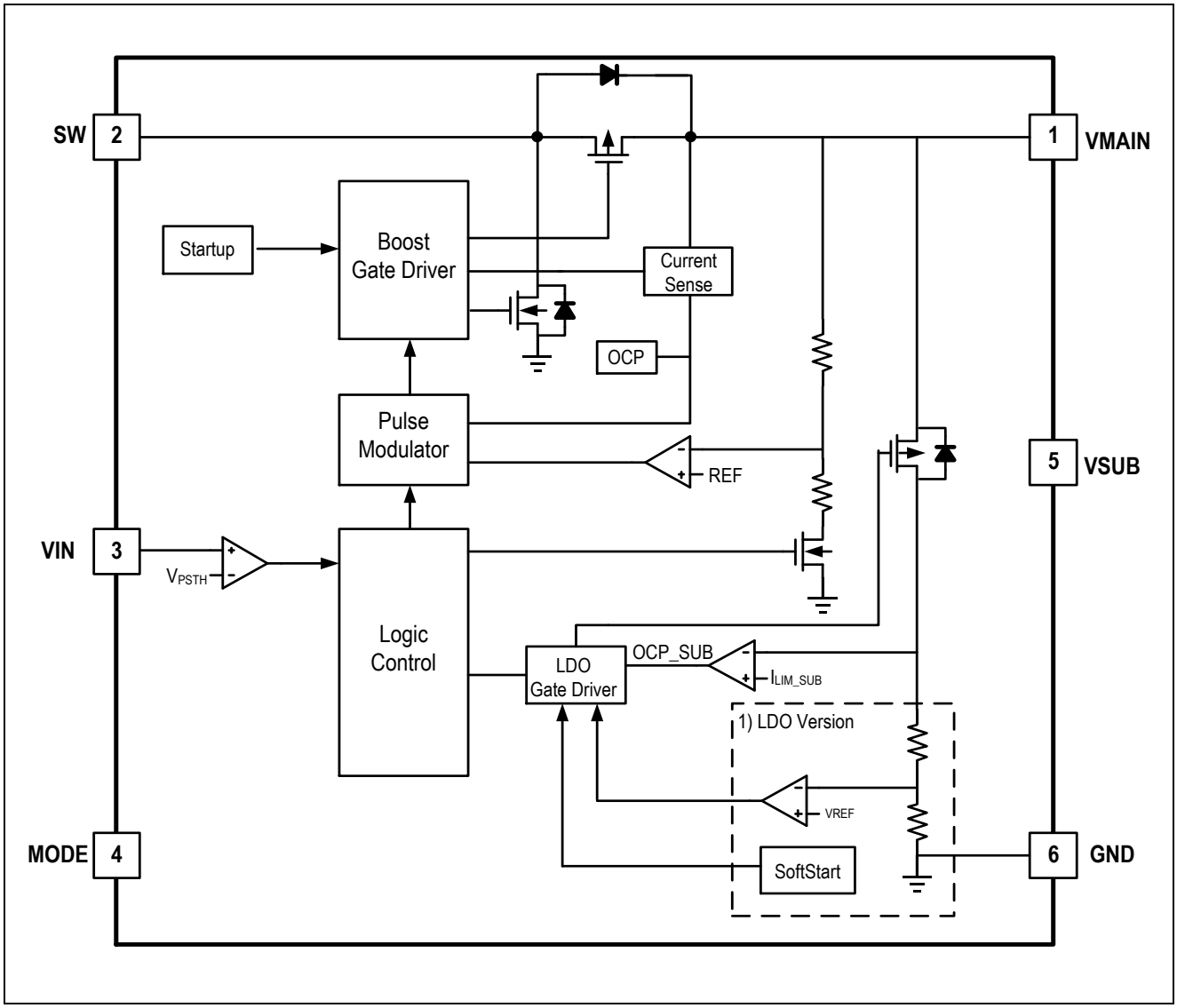


Top View (DFN6 1.5×1.5)

Pin Function

Pin Name	Pin No.	I/O	Description
VMAIN	1	PWR	Boost converter output
SW	2	PWR	Connection for inductor
VIN	3	I	IC power supply input
MODE	4	I	Mode selection pin. 1: Active mode; 0: Low Power mode. Must be actively tied high or low. Do not leave floating.
VSUB	5	PWR	LDO output
GND	6	PWR	IC ground

Block Diagram



Functional Description

Overview

The ET820982 is a low power solution optimized for products powered by either a one-cell or two-cell alkaline, NiCd or NiMH, one-cell coin cell battery or one-cell Li-Ion or Li-polymer battery. To simplify system design and save PCB space, the ET820982 integrates an LDO with a boost converter provide two output rails in a compact package. The boost output V_{MAIN} is designed as an always-on supply to power a main system.

The ET820982 features two modes controlled by MODE pin: Active mode and Low Power mode. In Active mode, both outputs are enabled, and the transient response performance of the boost converter and LDO are enhanced, so it is able to respond load transient quickly. In Low Power mode, the LDO is enable with low IQ. Besides that, the boost consumes only 4uA quiescent current in Low Power mode, low IQ can be achieved to extend the battery run time. The LDO is always on in both Active mode and Low Power mode. The main differences between the two modes of the ET820982 are the quiescent current and performance.

The ET820982 supports automatic pass-through function in both Active mode and Low Power mode. When VIN is detected higher than a pass-through threshold, which is around the target V_{MAIN} voltage, the boost converter stops switching and passes the input voltage through inductor and internal rectifier switch to V_{MAIN}, so V_{MAIN} follows V_{IN}; when V_{IN} is lower than the threshold, the boost works in boost mode and regulates V_{MAIN} at the target value. The ET820982 can support fixed V_{MAIN} target values in Active mode and Low Power mode to meet the requirements.

Boost Controller Operation

The ET820982 boost converter is controlled by a hysteretic current mode controller. This controller regulates the output voltage by keeping the inductor ripple current constant in the range of 100mA and adjusting the offset of this inductor current depending on the output load. Since the input voltage, output voltage and inductor value all affect the rising and falling slopes of inductor ripple current, the switching frequency is not fixed and is decided by the operation condition. If the required average input current is lower than the average inductor current defined by this constant ripple, the inductor current goes discontinuous to keep the efficiency high under light load conditions. Figure1 illustrates the hysteretic current operation. If the load is reduced further, the boost converter enters into Burst mode (Figure2). In Burst mode, the boost converter ramps up the output voltage with several pulses and it stops operating once the output voltage exceeds a set threshold, and then it goes into a sleep status and consumes less quiescent current. It resumes switching when the output voltage is below the set threshold. It exits the Burst mode when the output current can no longer be supported in this mode.

To achieve high efficiency, the power stage is realized as a synchronous boost topology. The output voltage V_{MAIN} is monitored via an internal feedback network which is connected to the voltage error amplifier. To regulate the output voltage, the voltage error amplifier compares this feedback voltage to the internal voltage reference and adjusts the required offset of the inductor current accordingly.

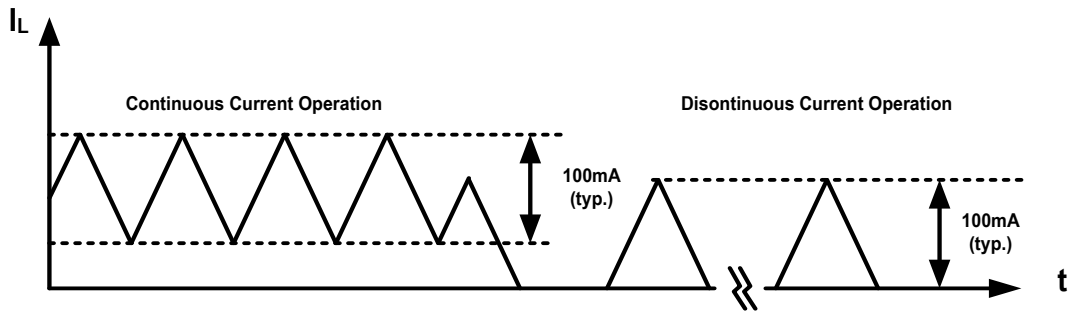


Figure1. Hysteretic Current Operation

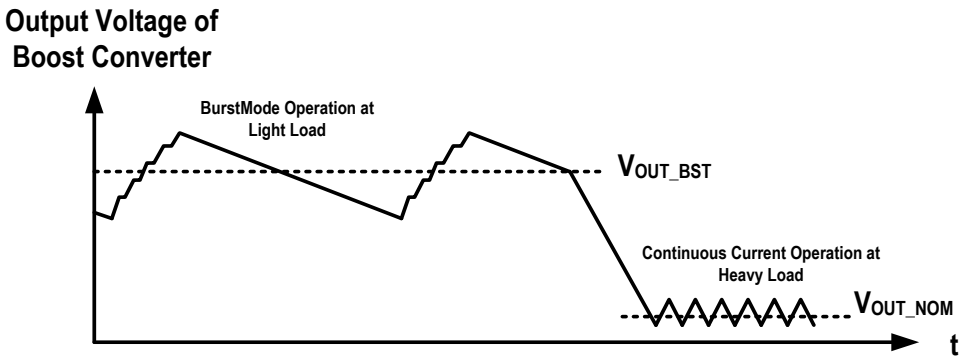


Figure2. Burst Mode Operation

Pass-Through Operation

The ET820982 supports automatic pass-through function for the boost converter. When the input voltage is detected higher than the pass-through threshold V_{PSTH}, which is around V_{MAIN} set value, the boost converter enters into pass-through operation mode. In this mode, the boost converter stops switching, the rectifier is constantly turned on and the low side switch is turned off. The input voltage passes through external inductor and the internal rectifier to the output. The output voltage in this mode depends on the resistance between the input and the output, calculated as Equation 1:

$$V_{MAIN} = V_{IN} - (I_{MAIN} + I_{SUB}) \times (R_L + R_{DS(ON)\_HS}) \quad (1)$$

where

- R_L is the DCR of external inductor
- $R_{DS(ON)\_HS}$ is the resistance of internal rectifier

When the input voltage is lower than VPSTH, the boost converter resumes switching to regulate the output at target value. The ET820982 can support automatic pass-through function in both Active mode and Low Power mode.

LDO Operation

The ET820982 uses a PMOS as a pass element of its integrated LDO. The input of the PMOS is connected to the output of the boost converter. When LDO is enabled, the PMOS is enabled to output a voltage on V_{SUB} pin.

For LDO version, the output voltage V_{SUB} is regulated at the set value when the voltage difference between its input and output is higher than the dropout voltage V_{DROP}, no matter the boost converter works in boost operation mode or pass-through operation mode. The V_{SUB} is monitored via an internal feedback network which is connected to the voltage error amplifier. To regulate V_{SUB}, the voltage error amplifier compares the feedback voltage to the internal voltage reference and adjusts the gate voltage of the PMOS accordingly. When the voltage drop across the PMOS is lower than the dropout voltage, the PMOS will be fully turned on and the output voltage at V_{SUB} is decided by Equation 2.

$$V_{SUB} = V_{MAIN} - I_{SUB} \times R_{LS} \quad (2)$$

where

- I_{SUB} is the load of V_{SUB} rail
- R_{LS} is the resistance of the PMOS when it is fully turned on

The LDO of the ET820982 is designed always-on, so there is no enable or disable control of it. When LDO is enabled, soft-start is implemented for the LDO versions to avoid inrush current during LDO startup. The start-up time of LDO is typically 1ms. ET820982 without the active discharge function, the V_{SUB} pin is floating, and its voltage normally drops down slowly due to leakage.

Start Up and Power Down

The boost converter of the ET820982 is designed always-on, so there is no enable or disable control of it. The boost converter starts operation once input voltage is applied. If the input voltage is not high enough, a low voltage startup oscillator operates the switches first. During this phase, the switching frequency is controlled by the oscillator, and the maximum switch current is limited. Once the converter has built up the output voltage V_{MAIN} to approximately 1.6V, the device switches to the normal hysteretic current mode operation and the V_{MAIN} rail starts to supply the internal control circuit. If the input voltage is too low or the load during startup is too heavy, which makes the converter unable to build up 1.6V at V_{MAIN} rail, the boost converter can't start up successfully. It will keep in this status until the input voltage is increased or removed.

The ET820982 is able to startup with 0.7V input voltage with ≥ 3kΩ load. The startup time depends on input voltage and load conditions. After the V_{MAIN} reaches 1.6V to start the normal hysteretic current mode operation, an internal ramp-up reference controls soft-start time of the boost converter until V_{MAIN} reaches its set value.

An under-voltage lockout (UVLO) circuit stops the operation of the converter when the input voltage drops below the typical UVLO threshold of 0.4V. A hysteresis of 150mV is added so that the device cannot be enabled again until the input voltage goes up to 0.55V. This function is implemented in order to prevent malfunctioning of the device when the input voltage is between 0.4V and 0.55V.When the input voltage drops to a low voltage and can't provide the required energy to the boost converter, the V_{MAIN} drops. When and to what extent V_{MAIN} drops are dependent on the input and load conditions. When the boost converter is unable to maintain 1.6V at V_{MAIN} rail to supply the internal circuit, the ET820982 powers down and enters into startup process again.

Over Load Protection

The boost converter of the ET820982 supports a cycle-by-cycle current limit function in boost mode operation. If the peak inductor current reaches the internal switch current limit threshold, the main switch is turned off to stop a further increase of the input current. In this case the output voltage will decrease since the device cannot provide sufficient power to maintain the set output voltage. If short to ground condition occurs, the short current is limited at about 300mA. Once the short condition is removed, the ET820982 goes back to soft start again and regulates the output voltage.

The overload protection is not active in pass-through mode operation, in which the load current is only limited by the DC resistance.

The integrated LDO also supports over load protection. When the load current of V_{SUB} rail reaches the I_{LIM_SUB}, the V_{SUB} output current will be regulated at this limit value and will not increase further. In this case the V_{SUB} voltage will decrease since the device cannot provide sufficient power to the load.

Thermal Shutdown

The ET820982 has a built-in temperature sensor which monitors the internal junction temperature in boost mode operation. If the junction temperature exceeds the threshold (150°C typical), the device stops operating. As soon as the junction temperature has decreased below the programmed threshold with a hysteresis, it starts operating again. There is a built-in hysteresis (25°C typical) to avoid unstable operation at the over temperature threshold. The over temperature protection is not active in pass-through mode operation.

Device Functional Modes

The ET820982 features two operation modes controlled by MODE pin: the Active mode and Low Power mode. It can provide quick transient response in Active mode and low quiescent current in Low Power mode. So a low power system can easily use the ET820982 to get high performance in its active mode and meantime minimize its power consumption to extend the battery run time in its sleep mode.

The MODE pin is usually controlled by an I/O pin of a controller, and should not be left floating.

Active Mode and Low Power Mode

The boost converter and LDO of ET820982 are always on in both Active mode and Low Power mode with higher quiescent current consumption than other versions. The transient response performance of the boost converter is enhanced in Active mode, and the device consumes around 15μA quiescent current. It is able to respond load transient quickly.

Burst Mode Operation under Light Load Condition

The boost converter of ET820982 enters into Burst Mode operation under light load condition.

Pass-Through Mode Operation

The boost converter of ET820982 automatically enters into pass-through mode operation when input voltage is higher than the target output voltage.

Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) (1)

Symbol	Parameters	Min	Max	Unit
V_{IN}, V_{SW}, V_{MAIN}, V_{SUB}	Input voltage	-0.3	4.7	V
V_{MODE}		-0.3	5.0	V
T_J	Operating junction temperature	-40	150	°C
T_A	Ambient temperature	-40	85	°C
T_{STG}	Storage temperature range	-65	150	°C

Note(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Thermal Characteristics

Symbol	Thermal Metric	Value	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	205	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	135	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	8	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	135	°C/W

Electrical Characteristics

T_A = -40°C to 85°C and V_{IN} = 0.7V to 4.5V. Typical values are at V_{IN} = 1.5V, T_A = 25°C, unless otherwise noted.

Symbol	Parameters	Test Conditions	Min	Typ	Max	Unit
Power Supply						
V_{IN}	Input voltage range		0.7		4.5	V
V_{UVLO}	Input Under voltage Lockout threshold	V_{IN} rising T_A =25°C		0.55	0.7	V
$V_{IN(start)}$	Minimum input voltage at start-up	R_{LOAD}≥3kΩ (2)			0.7	V
$I_{Q(VIN)}$	Quiescent current into the VIN pin in Active mode	V_{MODE} = High, Boost or Pass-through no load, no switching, T_A = –40°C to 85°C		2	4	μA
	Quiescent current into the VIN pin in Low Power mode	V_{MODE} = Low, Boost or Pass-through no load, no switching, T_A =25°C		5	90	nA

Electrical Characteristics(Continued)

T_A = -40°C to 85°C and V_{IN} = 0.7V to 4.5V. Typical values are at V_{IN} = 1.5V, T_A = 25°C, unless otherwise noted.

Symbol	Parameters	Test Conditions	Min	Typ	Max	Unit
$I_{Q(VMAIN)}$	Quiescent current into the VMAIN pin in Active mode	V_{MODE} = High, Boost or Pass-through no load, no switching, T_A = –40°C to 85°C		18	23	μA
	Quiescent current into the VMAIN pin in Low Power mode	V_{MODE} = Low, Boost or Pass-through no load, no switching, T_A = –40°C to 85°C		4	10	μA
$I_{LKG(SW)}$	Leakage current of the SW pin (from the SW pin to GND pin)	V_{MAIN} = V_{SW}= 4.7V, no load , T_A = –40°C to 85°C		5	100	nA
$I_{LKG(MAIN)}$	Leakage current of the VMAIN pin (from the VMAIN pin to SW pin)	V_{MAIN} = 4.7V, V_{SW} = 0V, no load , T_A = –40°C to 85°C		10	200	nA
$I_{LKG(MODE)}$	Leakage current into the MODE pin	V_{MODE}= 5V T_A = –40°C to 85°C		5	30	nA
Output						
$V_{(MAIN)}$	Boost converter output voltage	V_{MODE} = High / Low, V_{IN}< $V_{(PSTH)}$, Burst mode, open loop		3.4		V
		V_{MODE} = High / Low, V_{IN}< $V_{(PSTH)}$, PWM mode, open loop	3.201	3.3	3.399	V
$V_{(SUB)}$	LDO output voltage (LDO version)	V_{MODE} = High / Low	2.744	2.8	2.856	V
$V_{(PSTH)}$	Pass-through mode threshold	V_{MODE} = High / Low, V_{IN} rising		3.6		V
		V_{MODE} = High / Low, Hysteresis		0.1		V
PSRR	Power-supply rejection ratio from LDO input to output	f = 1kHz, C_{O2} = 10μF, I_{SUB} = 10mA , V_{MODE} = High		40		dB
		f = 1kHz, C_{O2} = 10μF, I_{SUB} = 10mA , V_{MODE} = Low		28		dB
t_{STUP_LDO}	LDO start-up time	No load,time from 90% of V_{MAIN} to 90% of V_{SUB}		1		ms
Power Switch						
$R_{DS(ON)\_LS}$	Low-side switch on resistance	V_{MODE} = Low / High		350	650	mΩ
$R_{DS(ON)\_HS}$	Rectifier on resistance	V_{MODE} = Low / High		500	700	mΩ

Electrical Characteristics(Continued)

T_A = -40°C to 85°C and V_{IN} = 0.7V to 4.5V. Typical values are at V_{IN} = 1.5V, T_A = 25°C, unless otherwise noted.

Symbol	Parameters	Test Conditions	Min	Typ	Max	Unit
Power Switch (Continued)						
V_{DROP}	LDO dropout voltage	I_{SUB} = 50mA		60	100	mV
I_{LH}	Inductor current ripple	V_{IN}=1.5V, I_{LOAD}(V_{MAIN})=100mA		100		mA
$I_{LIM(BST)}$	Boost switch current limit	0.7V < V_{IN} < V_{MAIN}	350	500	650	mA
$I_{LIM(SUB)}$	VSUB output current limit	T_A = -40°C to 85°C	200			mA
Control Logic						
V_{IL}	MODE input low voltage threshold				0.3	V
V_{IH}	MODE input high voltage threshold		1.2			V
T_{OTP}	Over temperature protection			150		°C
T_{OTP_HYS}	Over temperature hysteresis			25		°C

Note(2): ET820982 is able to drive R_{LOAD}> 150Ω after V_{MAIN} is established over 1.8V.

Typical Characteristics

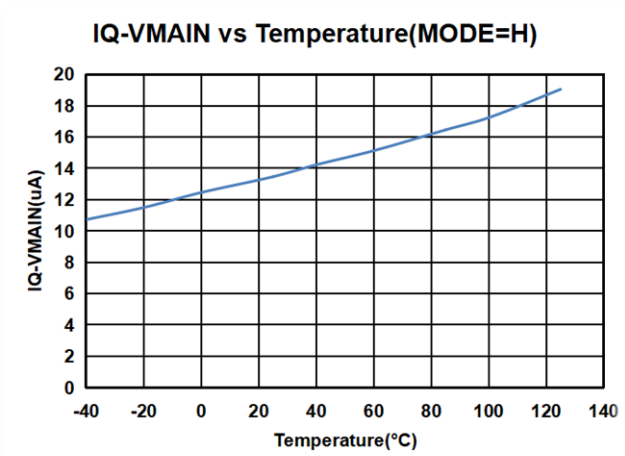


Figure3.IQ into VMAIN vs Temperature,MODE=H

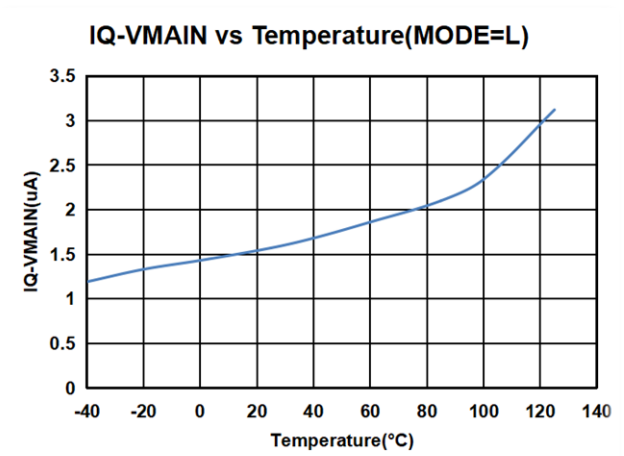


Figure4.IQ into VMAIN vs Temperature,MODE=L

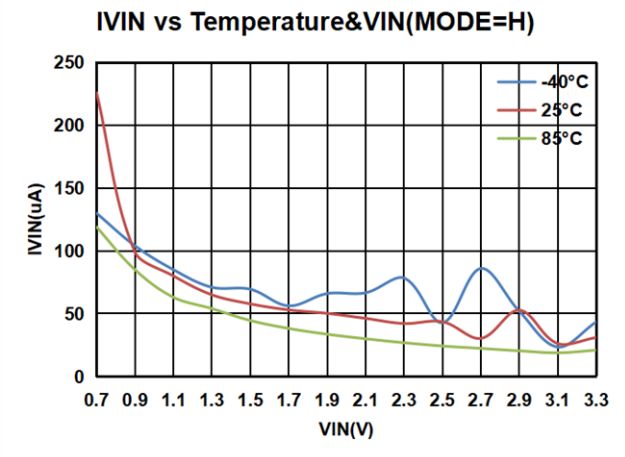


Figure5. Input current vs Temperature,MODE=H

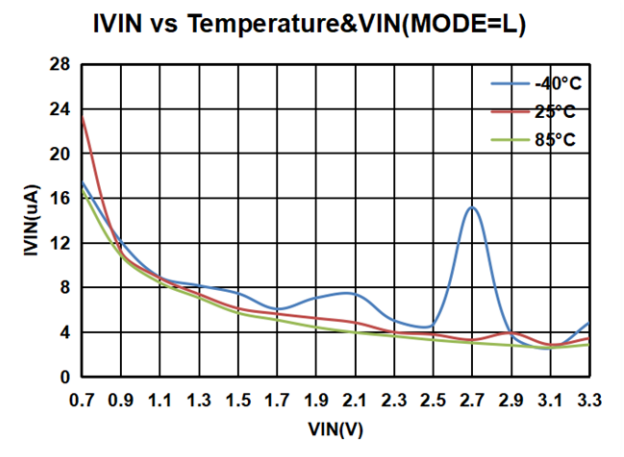


Figure6. Input current vs Temperature,MODE=L

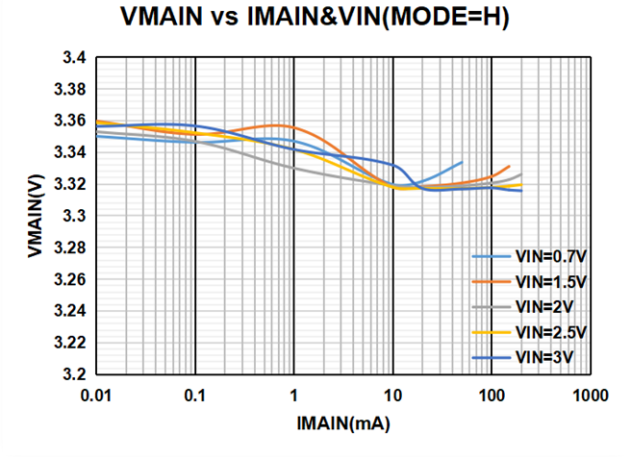


Figure7. VMAIN vs IMAN&VIN,MODE=H

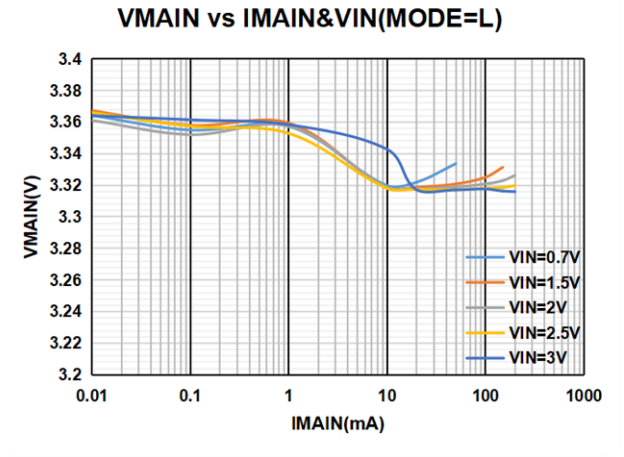


Figure8. VMAIN vs IMAN&VIN,MODE=L

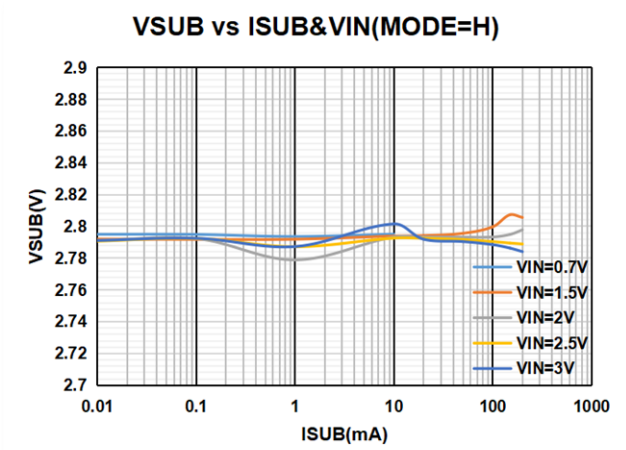


Figure9. VSUB vs ISUB&VIN,MODE=H

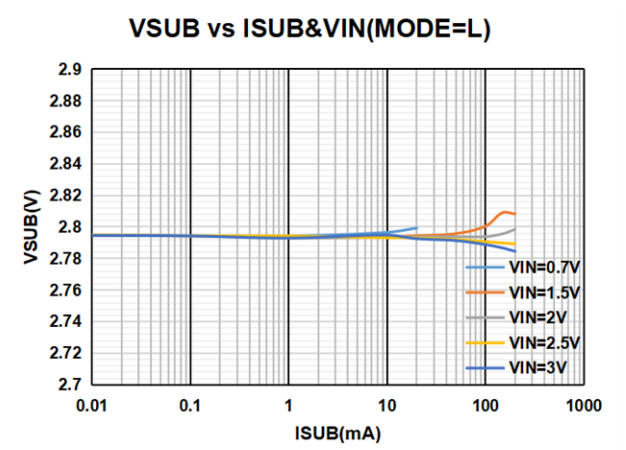


Figure10. VSUB vs ISUB&VIN,MODE=L

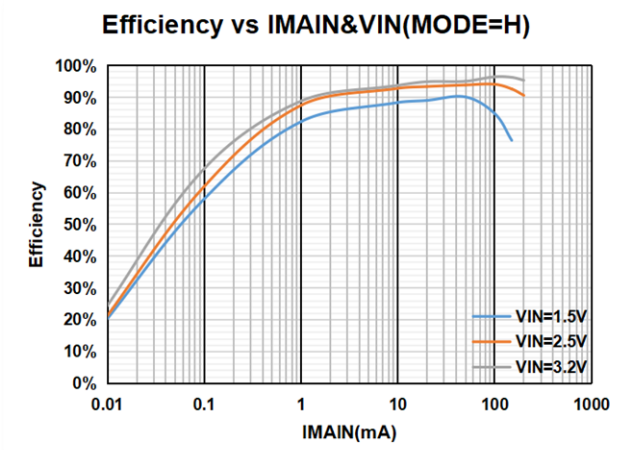


Figure11. Efficiency vs IMAIN&VIN,MODE=H

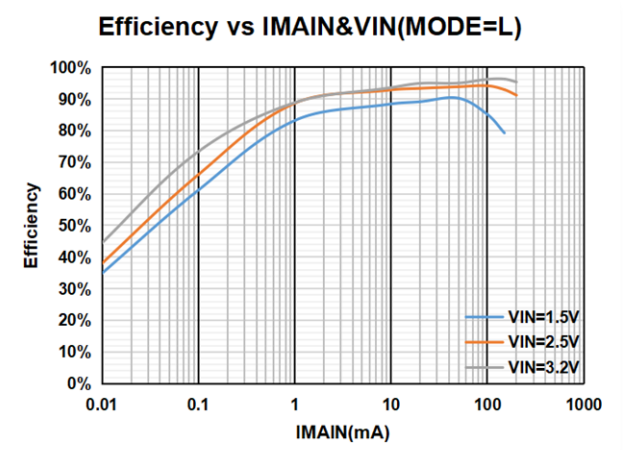


Figure12. Efficiency vs IMAIN&VIN,MODE=L

Application Curves

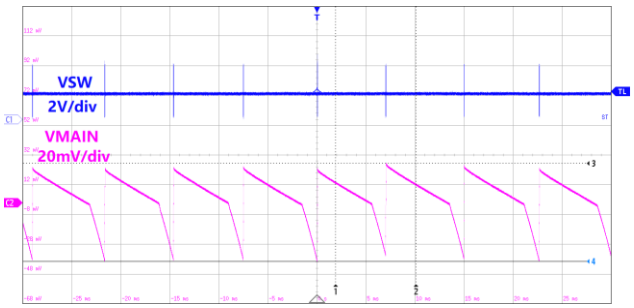


Figure13.Switch&Ripple Waveform,
VIN=1.5V,IMAIN=0mA,MODE=H

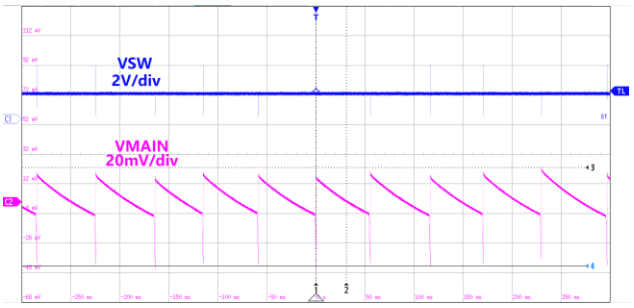


Figure14.Switch&Ripple Waveform,
VIN=1.5V,IMAIN=0mA,MODE=L

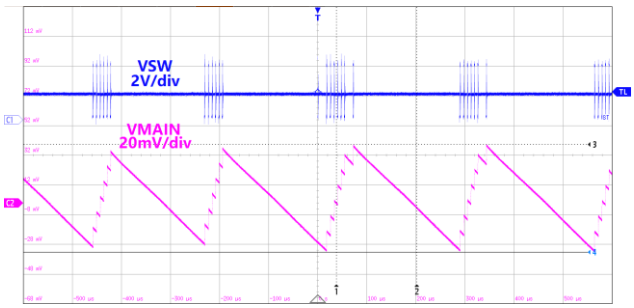


Figure15.Switch&Ripple Waveform,
VIN=1.5V,IMAIN=1mA,MODE=H

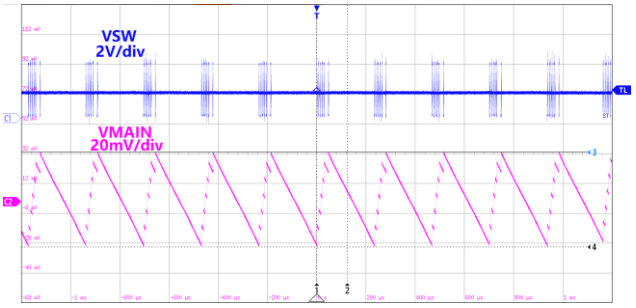


Figure16.Switch&Ripple Waveform,
VIN=1.5V,IMAIN=1mA,MODE=L

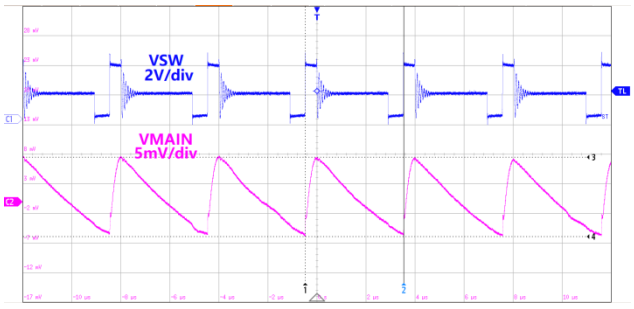


Figure17.Switch&Ripple Waveform,
VIN=1.5V,IMAIN=10mA,MODE=H

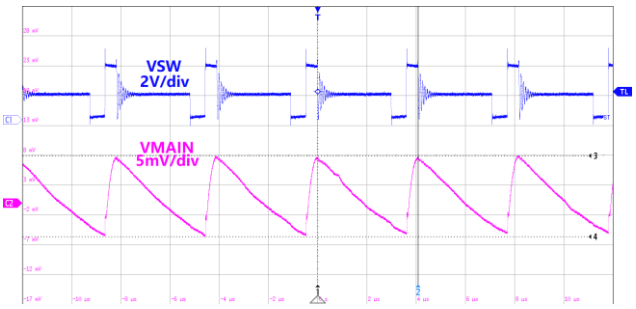


Figure18.Switch&Ripple Waveform,
VIN=1.5V,IMAIN=10mA,MODE=L

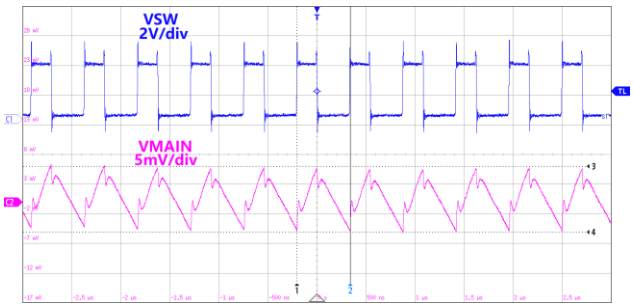


Figure19.Switch&Ripple Waveform,
VIN=1.5V,IMAIN=100mA,MODE=L

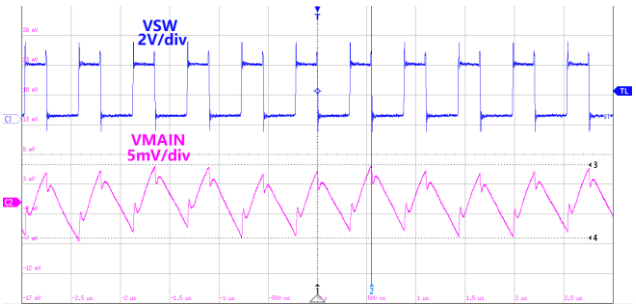


Figure20.Switch&Ripple Waveform,
VIN=1.5V,IMAIN=100mA,MODE=L

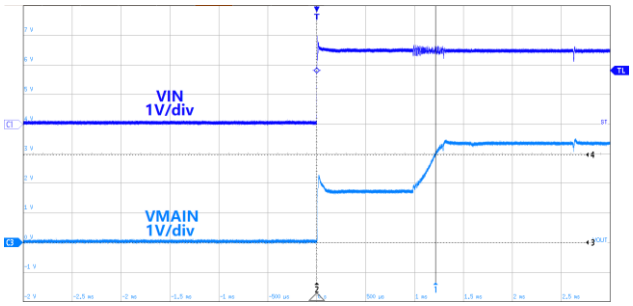


Figure21.Boost Soft Start Waveform
VIN=0~1.5V,IMAIN=100mA,MODE=H

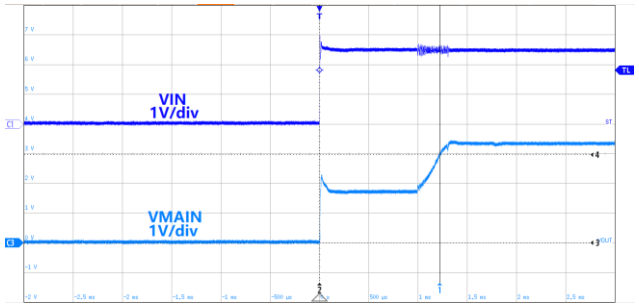


Figure22.Boost Soft Start Waveform
VIN=0~1.5V,IMAIN=100mA,MODE=L

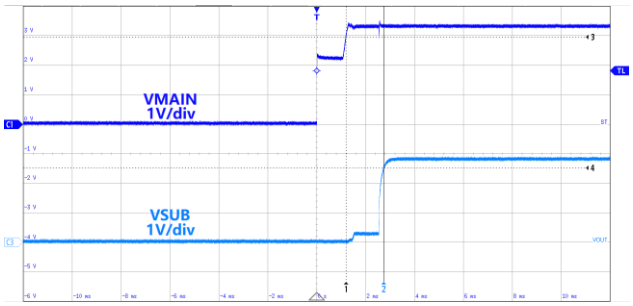


Figure23.LDO Soft Start Waveform
VIN=0~1.5V,ISUB=100mA,MODE=H

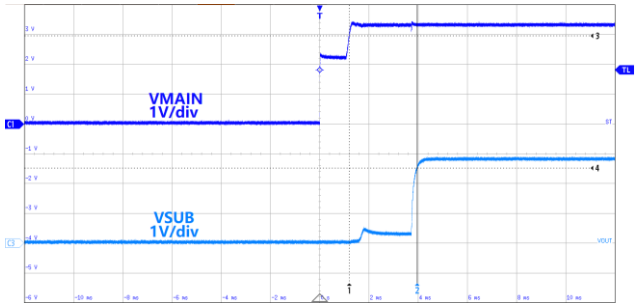


Figure24.LDO Soft Start Waveform
VIN=0~1.5V,ISUB=100mA,MODE=L

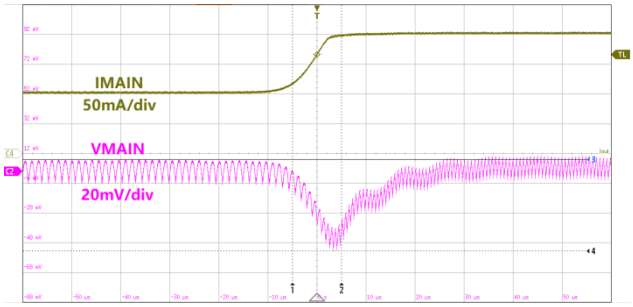


Figure25.Boost Load Transient Waveform,Rise
VIN=2.5V,IMAIN=100~200mA,MODE=H

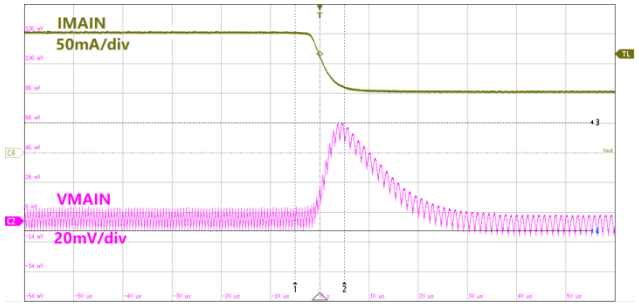


Figure26.Boost Load Transient Waveform,Fall
VIN=2.5V,IMAIN=100~200mA,MODE=H

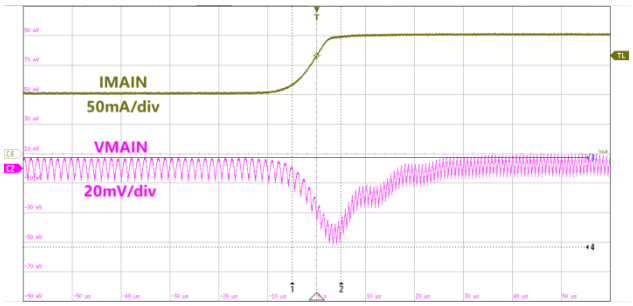


Figure27.Boost Load Transient Waveform,Rise
VIN=2.5V,IMAIN=100~200mA,MODE=L

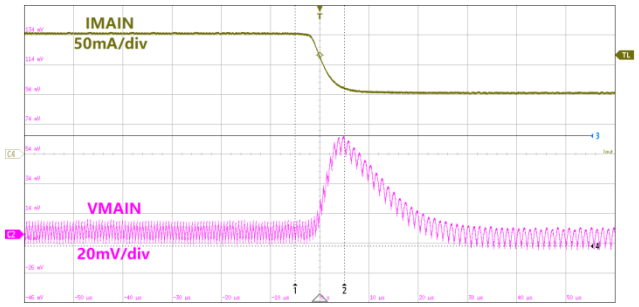


Figure28.Boost Load Transient Waveform,Fall
VIN=2.5V,IMAIN=100~200mA,MODE=L

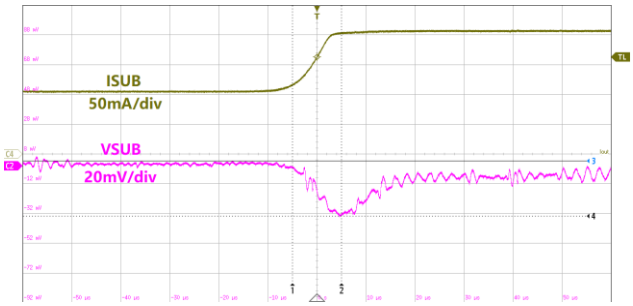


Figure29.LDO Load Transient Waveform,Rise
VIN=2.5V,ISUB=100~200mA,MODE=H

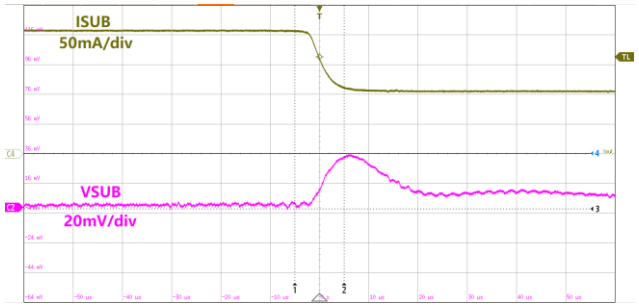


Figure30.LDO Load Transient Waveform,Fall
VIN=2.5V,ISUB=100~200mA,MODE=H

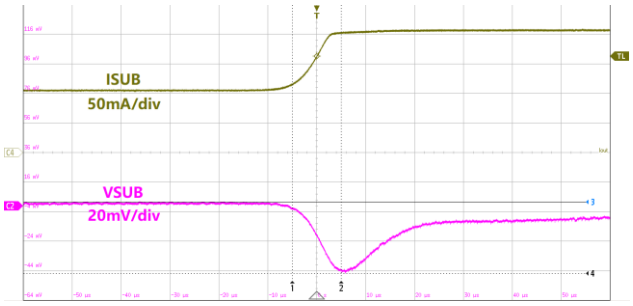


Figure31.LDO Load Transient Waveform,Rise
VIN=2.5V,ISUB=100~200mA,MODE=L

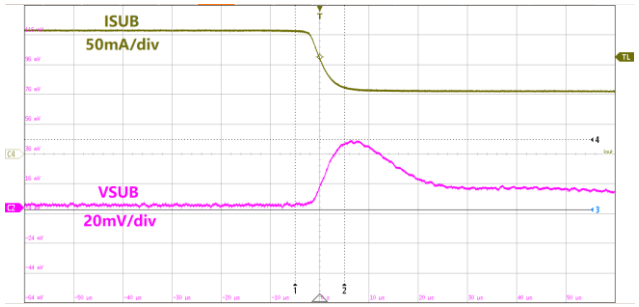


Figure32.LDO Load Transient Waveform,Fall
VIN=2.5V,ISUB=100~200mA,MODE=L

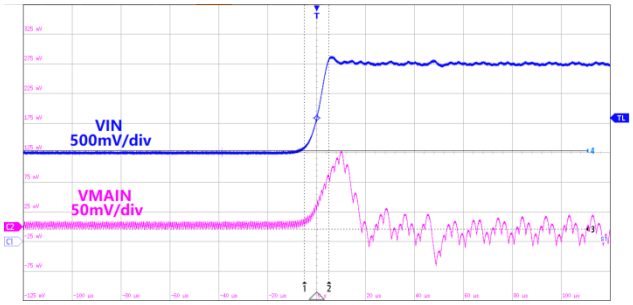


Figure33.Boost Line Transient Waveform,Rise
VIN=1.5~3V,IMAIN=100mA,MODE=H

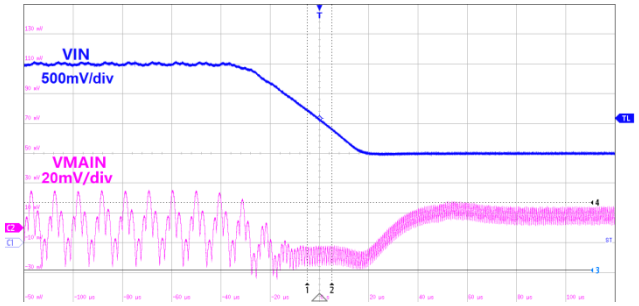


Figure34.Boost Line Transient Waveform,Fall
VIN=1.5~3V,IMAIN=100mA,MODE=H

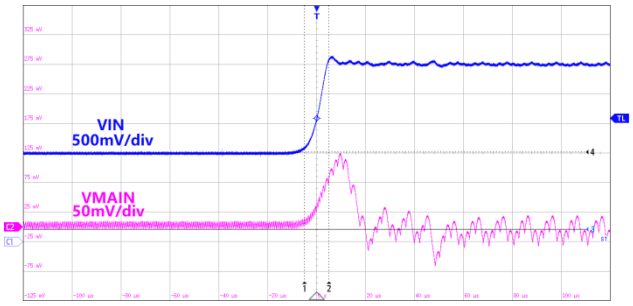


Figure35.Boost Line Transient Waveform,Rise
VIN=1.5~3V,IMAIN=100mA,MODE=L

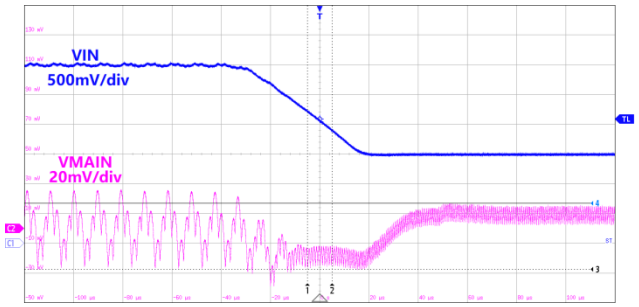


Figure36.Boost Line Transient Waveform,Fall
VIN=1.5~3V,IMAIN=100mA,MODE=L

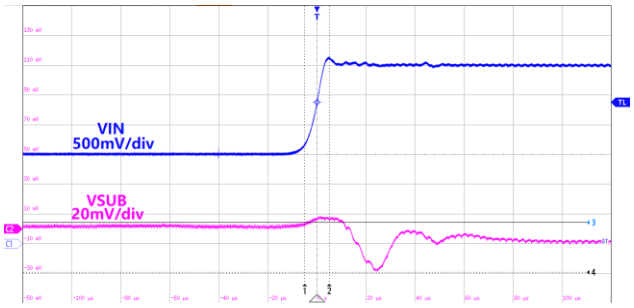


Figure37.LDO Line Transient Waveform,Rise
VIN=1.5~3V,ISUB=100mA,MODE=H

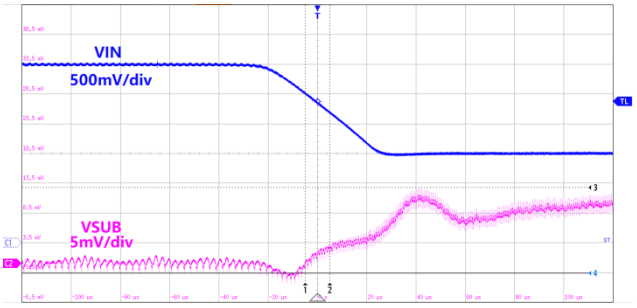


Figure38.LDO Line Transient Waveform,Fall
VIN=1.5~3V,ISUB=100mA,MODE=H

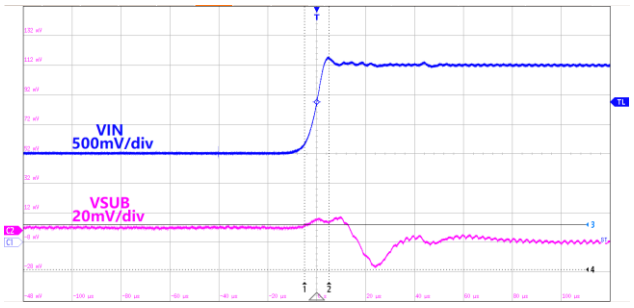


Figure39.LDO Line Transient Waveform,Rise
VIN=1.5~3V,ISUB=100mA,MODE=L

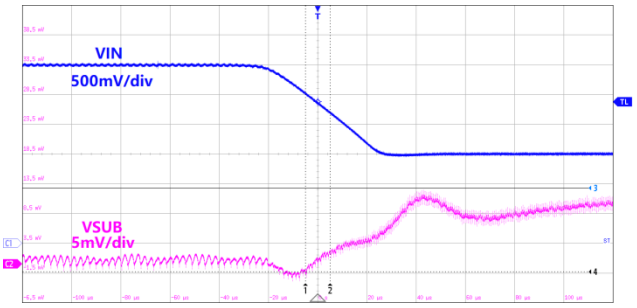


Figure40.LDO Line Transient Waveform,Fall
VIN=1.5~3V,ISUB=100mA,MODE=L

Application Circuits

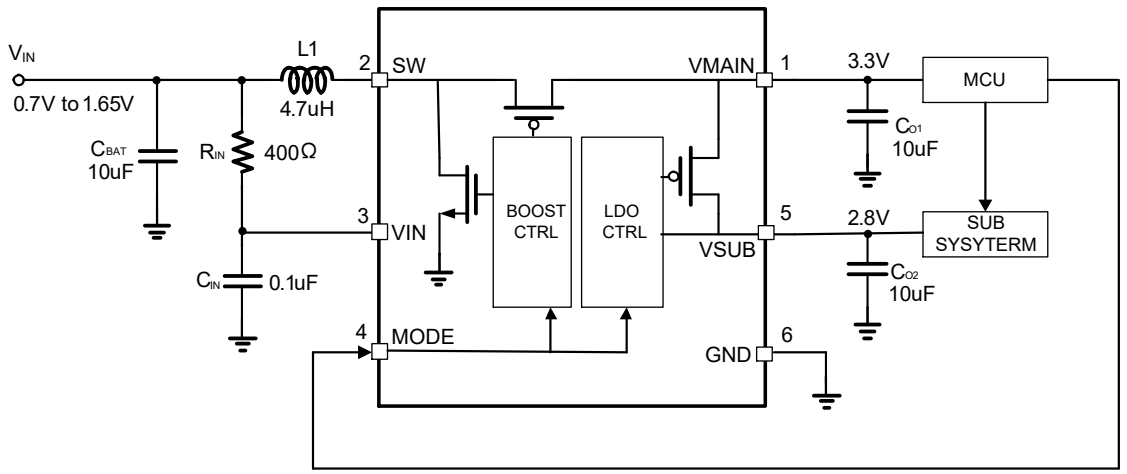


Figure41. Reference Circuits

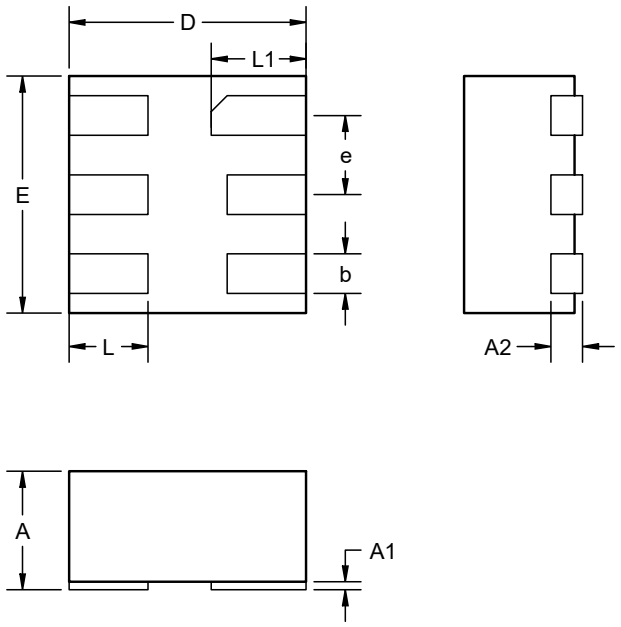
Application Information

The ET820982 is a low power solution for products powered by either a one-cell or two-cell alkaline, NiCd or NiMH, one-cell coin cell or one-cell Li-Ion or Li-polymer battery. It integrates a Low-dropout Linear Regulator (LDO) with a boost converter and provides dual output rails.

The V_{MAIN} rail is the output of the boost converter. The V_{SUB} rail is the output of the integrated LDO. They are all always-on outputs and can only be turned off by removing input voltage.

Package Dimension

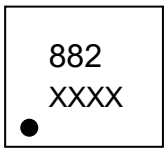
DFN6 (1.5 × 1.5)



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	—	0.05
A2	—	0.20	—
b	0.20	0.25	0.30
D	1.45	1.50	1.55
E	1.45	1.50	1.55
e	—	0.50	—
L	0.40	0.50	0.60
L1	0.50	0.60	0.70

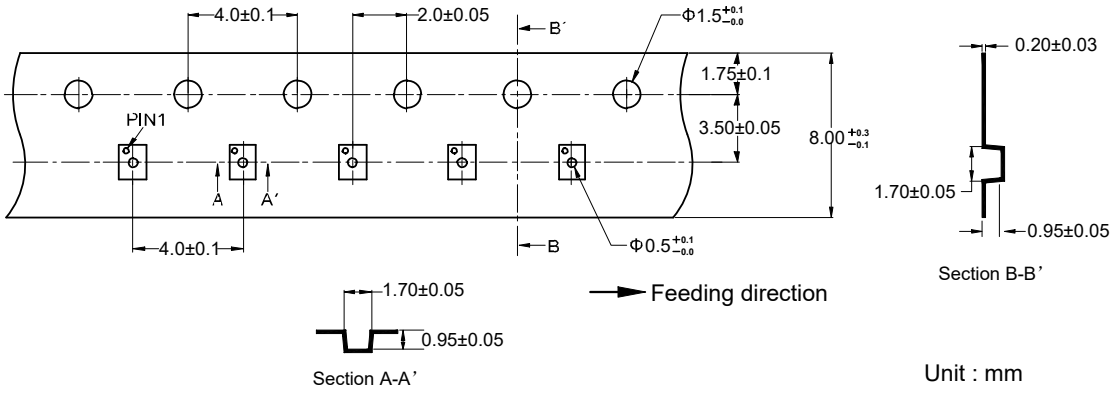
Marking



882 - Part Number

XXXX - Tracking Number

Tape



Revision History and Checking Table

Version	Date	RevisionItem	Modifier	Function & Spec Checking	Package & Tape Checking
0.0	2022.6.1	Preliminary Version	Lvds ,Shib	huangxx	
0.1	2022.8.5	Preliminary Version update	huangxx	huangxx	
1.0	2023.3.15	Official version	Liuc ,Shib	huangxx	